MALATHION PROTECTION OF INSHELL ALMONDS IN BULK STORAGE — PILOT SCALE STUDY

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The American Cyanamid Company provided the Cythion for treatment of the almonds. Their representative, Richard S. Nielsen, assisted in the treatments and took pictures of the operation.

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MALATHION PROTECTION OF INSHELL ALMONDS IN BULK STORAGE--PILOT SCALE STUDY

By G. H. Spitler, P. L. Hartsell, and H. D. Nelson[1]

SUMMARY

Malathion EL (emulsifiable liquid) applied to inshell almonds, which were stored in bulk bins in a warehouse, protected the nuts from insect damage for 9 months. Intended dosages were 4, 8, and 16 parts per million (p/m). GLC analysis detected 3.9, 11.07, and 19.7 p/m immediately after treatment and 3.2, 7.4, and 12.0 p/m after 10 months in storage.

Insect damage in four lots of 10 bins each of almonds at the start of the test ranged from 13 to 17.3 percent and was caused exclusively by navel orangeworm, *Paramyelois transitella* (Walker).

Each malathion EL treatment (10 bin lots) had, respectively, 13 percent (4 p/m), 17.3 percent (8 p/m), and 15 percent (16 p/m) damage by navel orangeworm. After the almonds were sprayed, the navel orangeworms migrated from the bins to other areas of the warehouse. Most of this migration was completed in the first 30 days of storage.

During the 10-month storage period, insect populations in the untreated nuts changed from predominantly navel orangeworm to predominantly Indian meal moths, *Plodia interpunctella* (Hübner). The net damage increase in 9 months of storage was 33.7 percent in the untreated almonds, 2.7 percent in the 4 p/m treatment, 0 percent in the 8 p/m treamtent, and 3.6 percent in the 16 p/m treatment. One month later, the treatments appeared to be failing because damage had increased, respectively, to 42.3, 15.3, 14.4, and 7.7 percent. The test was then terminated, and the processor was able to utilize approximately 90 percent of the treated nuts for food stock. The untreated lot was so heavily damaged it could only have been used for oil stock.

INTRODUCTION

During the past 5 years, more than 125,000 tons of inshell almonds were produced in California.[2] The crop estimate for 1974 is for more than 200,000 inshell tons. One almond handler processes 60 to 75 percent of the annual crop. As the almonds are received, many of them are immediately shelled, but shellers cannot keep up with deliveries. Thus, many inshell almonds are stored for varying lengths of time at existing atmospheric conditions before they are shelled. Shelled almonds are packaged in 100-lb bags and placed in cold storage until marketed.

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[2]United States Department of Agriculture. Agricultural statistics. 617 pp. U.S. Dept. Agr., Washington, D.C. 1973.

Most of the almond crop is delivered within a 45- to 60-day period between September and mid-November. These deliveries are almost 100 percent inshell almonds and are stored by varieties in bulk storage.

These inshell almonds should be fumigated, because many are infested with insects. Because of the rush at this time of year, fumigation may be delayed for more than 30 days. Not all bulk storage facilities are suitable for fumigation.

When the almonds are delivered by the growers in the fall, the principal insects found are the navel orangeworm, *Paramyelois transitella* (Walker); the peach twig borer, *Anarsia lineatella* Zeller; and the oriental fruit moth, *Grapholitha molesta* (Busck).[3] Two other species, the codling moth, *Laspeyresia pomonella* (Linneaus), and the filbertworm, *Mellissopus latiferreanus* (Walsingham), cause incidental damage, but may create a problem in a given year. In 1974, four of the five leading varieties, which comprised 93 percent of the total crop, had an average reject of 3.5 percent. This reject was principally insect damage, consisting of 7,943,223 shelled pounds.[4]

The longer the delivered nuts are held without fumigation during this critical period (September to mid-November), the greater the damage to the nutmeats. Preliminary work with inshell almonds has shown that malathion dust or spray applied uniformly on the nuts protects them from several storage insects for 9 to 12 months.[5] In intermediate studies, malathion sprays protected almonds for 1 year, preventing insect damage.[6]

The objectives of this study were to determine: (1) the effect of malathion EL (emulsifiable liquid) sprays in suppressing field infestations, and (2) the deposits (residues) of malathion needed to give this protection.

MATERIALS AND METHODS

Tri-Co Almonds, Inc., of Chico, Calif., provided 24 tons of inshell almonds and also storage facilities for this study. The test included 40 wooden bins, each holding approximately 1,000 lb of field run 'Nonpareil' almonds stored in a warehouse in Durham, Calif. Intended dosages were 0, 4, 8, and 16 parts per million (p/m) of malathion on the almonds. Each treatment was placed in 10 bins.

One month before the test began, this equipment was calibrated to spray 4, 8, and 16 p/m malathion EL (57-percent Cythion) on the inshell almonds. The shaker was adjusted to move 240 lb of nuts per minute through the spray of two nozzles mounted in tandem, approximately 1 foot apart (fig. 1). The nozzles delivered 720 ml of spray per minute per nozzle. Thus, 1,440 ml of spray was applied to 240 lb of almonds each minute. Field run almonds normally have a moisture content of 4 to 5 percent. Industry has requested that any protectant spray should not increase this moisture more than 1 percent; however, the nuts used in this study were very dry, and the 1.5 percent moisture content increase from the spray was tolerated by the processor.

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[3]C. E. Curtis, personal commun., 1974.

[4]California Almond Control Board. Almond receipts, production by county and by variety. 1974.

[5]Spitler, G. H., and P. L. Hartsell. Laboratory evaluation of malathion as a protectant for almonds during storage. Jour. Econ. Ent. 60(5): 1456-1458. 1967.

[6]Spitler, G. H., J. D. Clark, J. A. Coffelt, and P. L. Hartsell. Malathion as a protectant for inshell almonds during storage. Jour. Econ. Ent. 67(4): 535-536. 1974.

Figure 1.--Apparatus for spraying almonds with malathion EL.

The three dosages used in this test were mixed in the following portion:

1. 4 p/m = 25 ml of EL Cythion added to water to make 10,000 ml of spray solution.
2. 8 p/m = 50 ml of EL Cythion added to water to make 10,000 ml of spray solution.
3. 16 p/m = 80 ml of EL Cythion added to water to make 10,000 ml of spray solution.

The malathion was applied to the almonds at the plant in Chico in the following manner: A bin was dumped in a hopper located above a shaker. When the shaker was turned on, the nuts flowed through the spray from the two nozzles to an empty wooden bin. One bin at a time was treated in this way. Flow rates of nuts by the nozzles were regulated to be as close to 240 lb/min as possible. Thus, 1,200 lb was treated in 5 min. Because all almond hullers are not alike, flow rates varied, but 240 lb/min was the target. The results of the treatments were as follows:

Intended deposits	*Pounds flow/min*	*Minutes*	*Pounds treated*
Desired	240	5	1,200
4 p/m	[1]261.4	[1]5.08	[1]1,294.5
8 p/m	[1]207.2	[1]5.72	[1]1,175.6
16 p/m	[1]238.9	[1]4.85	[1]1,143.5
Average of 3 treatments:	235.8	5.25	1,204.5

[1]Average.

The application of sprays had little effect on the moisture content of the nutmeats. Moisture contents of the nutmeats before spraying and after 30 days in storage were practically identical.

No insects were placed in the storage area, but a warehouse was selected that had a record of infestation problems. None of the almonds were fumigated before or after delivery and were from a ranch where severe navel orangeworm damage could be expected.

Each month, samples of the almonds were taken from three locations in each bin at the surface, middle, and bottom. Sample size was approximately 100 grams per location. From each location, 10 inshell almonds were selected for damage evaluation (evidence of insect feeding) and live insect activity; thus, 30 nuts were examined from each bin. Each nut was shelled by hand, and the nutmeat was examined under a binocular microscope. This examination was considerably more critical than the procedure used by processing plants in the almond industry where almonds are examined on the sorting belts by the unaided eye. With the aid of the microscope, minute damage (where only several insect mandible marks had been made) was easily detected.

The samples not used for damage detection were pooled, and 100-gram samples were selected from the lot and used for malathion residue determination by GLC flame photometric detection. This method of detection is a modification of the one used by Mills et al.[7]

RESULTS

Table 1 shows the increase in damage to the almonds at monthly intervals for each treatment. The percentages shown in the table were based on numbers of nutmeats having evidence of insect damage. Damage to the untreated nuts was much more severe than damage to the treated almonds, but in this table the degree of damage is not shown. Often, damage to untreated almonds was such that the nutmeats were almost completely destroyed, whereas in treated almonds damage often consisted of a few mandible marks on the germ end of the nutmeat. Damage, as recorded in the table, increased from 3 to 33.7 percent within 9 months of storage in the untreated almonds; however, in the three treatments during the same storage period, 23 of the 27 samples had less than 3 percent damage, and the remaining 4 samples had 3.0, 3.6, 3.7, and 5.7 percent damage. Utilization of 90 percent of the treated nuts at the end of the storage attests to this degree of damage, whereas in the untreated nuts, from the third month of storage on, damage was so severe that utilization for anything other than oil stock would have been cost prohibitive.

Table 2 shows the deposits of malathion found on the inshell almonds, the shells only, and the nutmeats. The residues in the lowest treatment ranged from 3.9 to 2.3 p/m (average, 3.2); thus, a 3-p/m deposit of malathion would assure excellent protection. Note also that the highest residue found on the nutmeats (6.2 p/m) in the 16-p/m treatment was well below the 8-p/m tolerance now allowed by law on almond meats. This deposit of malathion occurred in the second month of storage, and by the tenth month of storage the highest residue found on the nutmeats was 2.7 p/m.

Figure 2 *A*, *B*, *C*, and *D* shows a typical bin from each treatment in which almonds were stored. These pictures were taken when the almonds were removed

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[7]Mills, P. A., J. Onley, and R. Gaither. Rapid method for chlorinated pesticide residues in nonfatty foods. Assoc. Off. Agr. Chem. Jour. 46(2): 186-191. 1963.

Table 1.--*Net increase of insect damage to stored nutmeats from monthly samples of 300 inshell almonds examined per treatment*

Treatment (p/m)	Damage at start	Percentage of insect damage found after the following months of treatment									
		1	2	3	4	5	6	7	8	9	10
Untreated	17	3	4	10.4	11.7	13	10.7	14.4	16.3	33.7	42.3
4	13	0	0	0	1.0	0	2.0	5.7	2.3	2.7	15.7
8	17.3	0	0	0	2.1	0	0	1.7	0	0	14.4
16	15	0	0	0	0	1.0	3.7	.3	3.0	3.6	7.7

Table 2.--*Residues of malathion found on inshell almonds, shells, and nutmeats determined by using GLC flame photometric detection*

Treatment	Start of test	Parts per million of malathion found after the following months of storage									
		1	2	3	4	5	6	7	8	9	10
Untreated:											
Inshell almonds	0.01	0.01	0.04	0.04	0.04	0.03	0.02	0.05	0.02	0.02	0.02
Shells only	.06	.06	.10	.06	.09	.54	.04	.14	.09	.07	.10
Nutmeats	.03	.0	.02	.02	.02	.05	.02	.03	.02	.02	.02
4 p/m:											
Inshell almonds	3.9	3.6	2.7	2.6	2.3	2.4	3.7	3.2	3.5	3.4	3.2
Shells only	---	6.7	7.5	6.5	9.5	12.4	10.9	7.5	10.0	9.1	8.6
Nutmeats	.22	.20	1.0	.43	.38	.37	.44	.47	.54	.43	.26
8 p/m:											
Inshell almonds	11.1	7.7	9.1	7.8	5.7	6.5	9.2	9.0	7.5	7.4	7.4
Shells only	---	11.7	19.4	16.4	26.0	27.2	28.0	17.8	27.4	16.2	15.4
Nutmeats	.65	.67	1.64	1.00	1.18	1.22	1.10	1.07	1.20	.90	.87
16 p/m:											
Inshell almonds	19.7	16.6	18.5	13.9	12.2	12.6	15.8	15.2	14.2	12.5	12.0
Shells only	---	17.6	51.0	39.2	40.0	42.0	43.0	32.0	40.0	28.0	29.0
Nutmeats	1.50	1.95	6.24	2.76	2.50	3.20	4.45	2.24	2.70	2.70	2.65

from the bins at the end of the study. Figure 2 *A* and 2 *C* shows considerable evidence of insect activity by the navel orangeworm. However, damage continued to increase in the untreated bins, but did not in the three lots of treated bins (table 1). These almonds (the 8-p/m treatment) initially had the heaviest insect infestation of navel orangeworm, 17.3 percent, yet the nuts were consistently low in damage for 9 months of storage (table 1).

After the spray was applied, the navel orangeworm pupated or crawled from the bins as mature larvae. Those that pupated, fastened many of the almonds to the bin walls with their cocoons. Some of these died in the pupal state, others emerged, laid eggs, and ultimately died as first instar larvae. The remainder probably left the bins after emerging, for damage ceased. The only difference

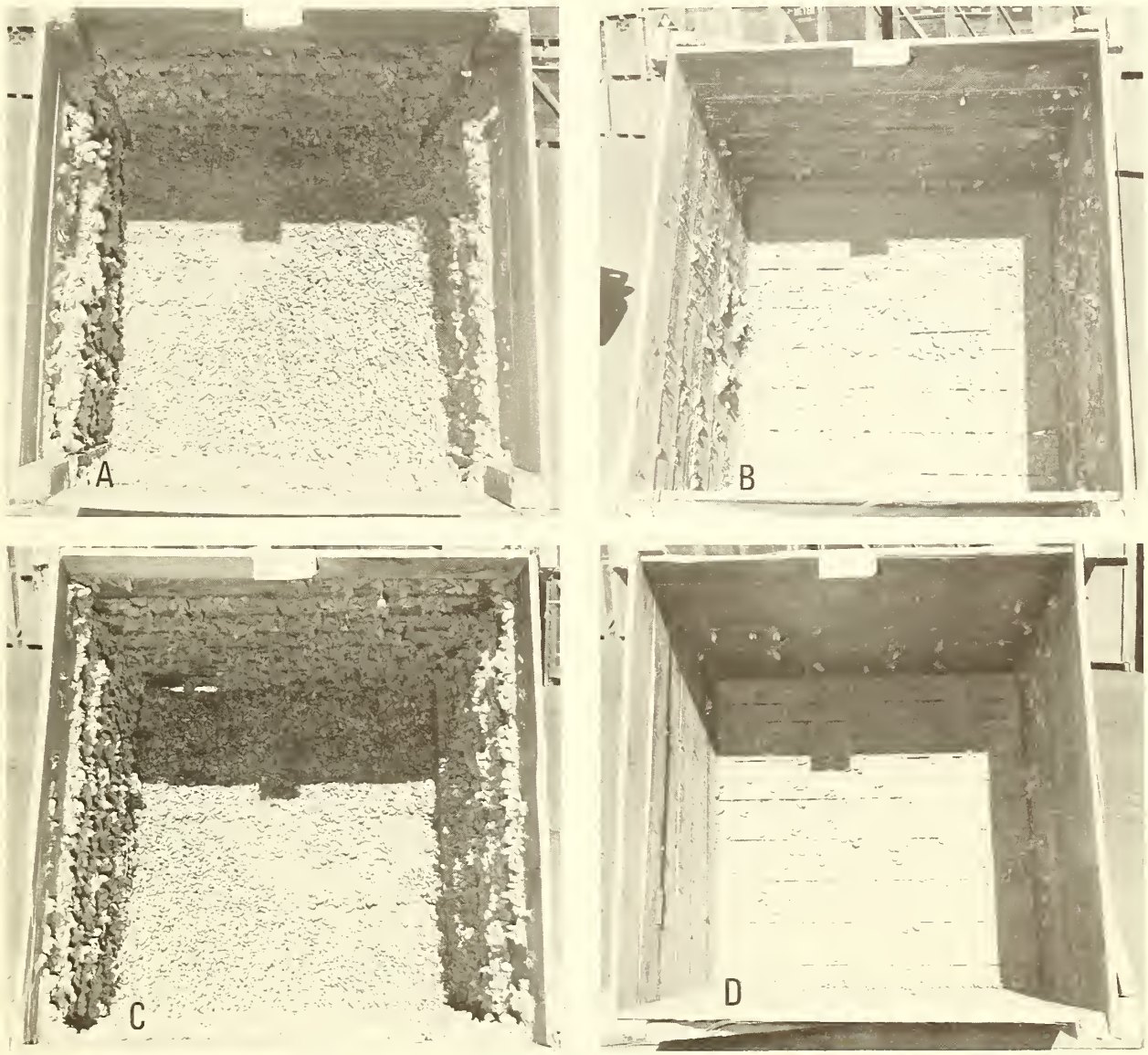

Figure 2.--Typical storage bins from each treatment in which almonds were stored 10 months and then emptied. Note the relative numbers of nuts stuck to navel orangeworm webbing on bin walls. *A*, Untreated almonds; *B*, almonds treated with 4 p/m malathion EL; *C*, almonds treated with 8 p/m malathion EL; *D*, almonds treated with 16 p/m malathion EL.

between the untreated and treated bins was that malathion EL was applied to the nuts. All other conditions were almost identical, yet damage increased and large numbers of adult navel orangeworms were present in the untreated bins, but not in the bins of the three treatments.

Within 1 week after the 30 bins containing the treated almonds were moved from the processing plant (where the malathion EL was applied) to the warehouse storage area, there was a mass exodus of mature navel orangeworm larvae from the bins. Navel orangeworm larvae continued to leave these treated nuts for the next 30 to 60 days. The concrete floor around the treated bins became slick with crushed larvae. No insects were observed crawling from the untreated bins; however, orangeworm moths were observed to increase each month until the arrival of cold warehouse temperatures. Most of the navel orangeworm larvae that crawled out from the treated bins were destroyed either by the protective treatment or by a mechanical sweeper used to clean the area.

Average moisture content at the start of the test was 4.5 percent of the nutmeats. During the winter month of February, moisture content rose to a high of 6.6 percent. At the end of storage, the moisture had dropped back to 5.4 percent. Thus, the 1.5-percent increase in moisture caused by the spray treatments had no adverse effect on storage moisture of the nuts.

All of the inshell almonds were removed from storage for processing by Tri-Co Almonds, Inc., after termination of the test. The untreated bins were so heavily damaged that the only way to salvage them was to use them for oil stock. The nuts from the three treatments were processed and yielded 90-percent useable, shelled nutmeats.

DISCUSSION

Whether the malathion EL spray would have actually killed the mature navel orangeworm is unknown, but extremely large numbers of larvae left the treated nuts and were no longer a factor in causing additional damage to the nutmeats. This attests to the repellency of the malathion.

During the 10-month storage period, insect populations in the untreated nuts changed from predominantly navel orangeworm to predominanatly Indian meal moths, *Plodia interpunctella* (Hübner). This transition took place within the sixth through the seventh month of storage. Thus, the navel orangeworm remained a storage pest longer than previously thought, and the Indian meal moth did not become the main storage pest until much later.

The authors were able to see minute damage with a binocular microscope; therefore, the 15-percent insect damage we reported would translate to 5 to 7 percent if industrial standards were used. Because of this difference in the method of estimating insect damage, processors (as noted in the "Results" section) were able to obtain a 90-percent yield of useable nutmeats from the three lots of treated nuts.

CONCLUSIONS

Application of malathion EL spray to newly harvested inshell almonds will protect the nuts from further insect damage during storage for 9 months or more provided deposits of malathion on the almond nutmeats are within the range of 1.5 to 4.0 p/m. This is well below the allowable tolerance of 8 p/m.

The 1.5-percent increase in moisture content, needed to apply the malathion EL spray, did not adversely effect the stored nuts. This, however, would not be true in an extremely wet harvest year, which is very uncommon in California.

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PRECAUTION

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State Extension specialist to be sure the intended use is still registered.

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